Whitepaper
TFASOFT

Functional specification and software architecture for citizen electoral transparency

Contents

1. Introduction

The purpose of this whitepaper is to provide a detailed specification of all the components required to build the TFASOFT software, in line with the vision of the TFA-CAM (Transparency For All in Cameroonian Elections) manifesto. Once implemented, TFASOFT will be a web and mobile application (Android and iOS) that will enable every Cameroonian citizen to actively contribute to electoral transparency by reporting the results of their polling station and following the national vote count in real time.

The functional specification presented in this document is the result of extensive consultation with Cameroonian citizens, including members of political parties, journalists, and members of civil society organizations. The leitmotif of this consultation was to ensure that the ideas to be codified in the software take into account the sum of experiences encountered in past elections in Cameroon and the pitfalls that have often marred them.

The resulting software system will establish a transparent, decentralized, and secure national consensus base, which should resolve the problem of fragmented information sources, which is an almost systematic pretext for endless disputes over the reliability of each source.

2. TFASOFT Mission Statement

TFASOFT is a software application designed on a clear ambition: to restore Cameroonian citizens' confidence in the results of elections organized in their country. In a context where the opaque centralization of election results fuels suspicions of fraud and undermines the legitimacy of democratic processes, TFASOFT proposes a radical break with the past, based on transparency, citizen participation and distributed technology.

One of the software's fundamental objectives is to enable every citizen, from his or her cell phone, to actively contribute to the consolidation of a national electoral consensus. This involves an essential functionality: the input of results from the polling station personally attended. To ensure that this contribution is unique, reliable and traceable, TFASOFT assigns a unique identifier to each device, which is combined with the user's telephone number upon authorization to prevent any attempt at double submission.

Secondly, TFASOFT aims to provide a real-time overview of election results at all levels of Cameroon's electoral administrative hierarchy. From a clear, interactive dashboard, users will be able to consult the evolution of votes compiled from the most local level (the polling station) to the national level, via the polling center, the electoral district, the department and the region. At each level, results are presented with consensus and reliability indicators, making them easy to read and compare.

The heart of the system is based on a consensus validation mechanism, configured via a *poolConsensusLevel* constant, enabling only results that have been confirmed by a qualified majority of independent users who have entered the same data for the same polling station

to be considered valid. This innovative mechanism ensures distributed self-verification of results, without a centralized actor arbitrarily imposing a single truth.

TFASOFT also emphasizes transparency through the collection and display of visual evidence. Each citizen can accompany his or her submission with photos or videos captured in his or her polling station, ensuring complete traceability of data. These media files enable other citizens to visually verify the conformity between the declared results and the documents displayed at the polling stations.

Finally, the objective of resilience is essential. TFASOFT provides sophisticated local data caching mechanisms on the user device. This means that, even if the Internet is cut off on polling day, the data entered remains saved and can be transmitted automatically as soon as connectivity is restored, or via a local mesh network between telephones. Thanks to this resilience, the electoral information chain no longer depends on a single, vulnerable infrastructure, but can rely on the collective strength of citizens connected to each other.

TFASOFT's objectives can be summarized as follows:

- Enable each citizen to **enter the results observed in his or her polling station, in a secure, unique and verifiable way**.
- **Display election results in real time at all hierarchical levels**: polling station, voting center, electoral district, department, region, national.
- Provide a **mechanism for consensual validation of observed results**.
- Ensure **data transparency and traceability through the uploading of visual evidence** (photos and videos).
- Ensure the **application's resilience in the event of Internet outages** by caching and synchronizing local information via an alternative multi-mode network (Wi-Fi Direct/Bluetooth Mesh).

3. The citizen at the heart of the consensus

TFASOFT software will bring about an unprecedented citizen consensus, where the truth of the ballot box will be spoken and known by all citizens. We are therefore at the dawn of a paradigm shift in electoral matters in Cameroon, where until now, a handful of people have arrogated to themselves the privilege of compiling all election results, with a strong suspicion of tampering at every opportunity.

This objective presupposes a robust component which, on the one hand, will authenticate and authorize users supplying information, and on the other, will establish rules for information intelligence and the detection of manipulation attempts by potential bad actors. A bad actor is one who does not want to follow simple transparency standards, but instead seeks to cheat.

This chapter describes the functional requirements of the component dedicated to user management and the rules governing their participation in the consensus.

Any user can provide his or her telephone number and password to create an account in TFASOFT and thus be able to post results information on the day of the vote after counting.

Since the sources and verification of results information are essential to the reliability of the overall consensus results, TFASOFT will distinguish between users who have created an account, those who will be referred to as FAIR (Active Information and Results Providers) and others.

A FAIR is a user who, in addition to having created an account, has provided some other essential information for identity verification, such as surname, first name, polling station, CNI or receipt number and a photo of his/her CNI or receipt, which the user can also simply film using the application. In the event of, this information can be used to identify bad actors attempting to provide false information in the application.

The information provided by a FAIR user is called FAIR itself. Any user who has created an account can provide information on results with supporting photos and videos, but only results provided by FAIR users will be taken into account by the consensus. Each user has the opportunity to provide the necessary information until noon (12:00) on polling day to become a FAIR user.

Each user can enter results information for a single polling station. For a FAIR user, the information provided must be that of the polling station registered in TFASOFT. If a FAIR registered user provides a result for a polling station other than the one registered in TFASOFT, this result will not be considered FAIR and will therefore not be taken into account in the consensus.

On polling day, any user can choose any polling station and see the list of NIC or receipt numbers of FAIR users registered for the chosen polling station. This allows everyone to check whether their FAIR registration has been taken into account, and at the same time enables all users to monitor to ensure that there are no FAIR users registered for a polling station to which they do not actually belong. Any attempt at fraud at this level must be reported by any user on the platform, which will be dedicated to all disputes arising from the use of TFASOFT. Any user found to have committed fraud at this level loses his or her FAIR user status.

The photos and videos (all called images in a word) that will be taken into account in TFASOFT will be those taken in and around the polling station on polling day between 6pm and a maximum of 10pm. Even if, for various reasons, the transmission of images and other information to the servers is delayed, the metadata of these images must indicate that they were taken within this timeframe for the images to be considered.

In addition to the polling station results that any user can enter via TFASOFT's simple, intuitive interface, users can also post up to 10 images taken in and around the polling station. These images can include a maximum of 2 videos of up to 30 seconds each. Given the limited number of images per user, it is therefore highly desirable that each user concentrates on providing the most relevant images possible of his or her polling station, such as, for example, the board

where the results are written down, the minutes signed by the scrutineers and representatives of the political parties, and so on.

In all, the use of TFASOFT will enable :

- All citizens to **see the evolution of results in real time**.
- Everyone to register as a **FAIR user** to provide **relevant voting information and images**.
- Everyone to register simply with their telephone number and a password to be able to **report any irregularities observed on the data** provided by FAIR users. A simple account also gives the possibility of providing information on the vote, but this information is not considered in the consensus as FAIR information (provided by FAIR users).

4. Functional specifications

Following the description of the user-centric component in the previous chapter, this chapter will focus on the components in charge of results entry, consensus management, Web and Mobile visualization, the caching system and the citizen alert system.

4.1 Results capture

Results entry is the core function of the TFASOFT mobile application. It is through this interface that each citizen contributor, witnessing the count in a polling station, actively participates in the construction of a distributed and transparent electoral consensus. It is therefore essential that this stage is intuitive, secure, precise and sufficiently flexible to guarantee universal use while preserving the integrity of the process.

When a FAIR user accesses the results entry page, the application automatically presents him/her with the polling station associated with his/her FAIR ID. This membership link is irrevocable, to prevent any attempt at double declaration or fraud. The data entry interface displays the complete list of candidates or political parties in the running, in the order validated at national level, with a numerical field for each candidate to enter the exact number of votes obtained in the polling station concerned.

The interface is designed to operate in both online and offline environments. It dynamically loads pre-configured polling data, enabling lag-free data entry even on modest devices. Each entry is syntactically validated (numerical values, consistent totals, absence of duplicates) and triggers a confirmation request from the user before final saving. Once confirmed, a summary is presented to the user before the data is finally locked on the device.

An essential dimension of transparency lies in the visual evidence accompanying data entry. Each user can add up to 10 media files, including photos and videos taken in or around the polling station. These media files must show elements such as the vote summary table, the minutes signed by scrutineers and party representatives, or any other evidence of the vote

count. Videos are limited to a length of 30 seconds to ensure fast loading, and only images whose metadata attests that they were taken on polling day, between 6pm and 10pm, are considered valid by TFASOFT.

Once an entry has been validated, the user can no longer modify it. The data entered is instantly marked as "issued", and depending on the network context, is either transmitted to the server or stored in a secure cache for later synchronization. A digital signature of all data (results and associated files) is generated locally to guarantee the authenticity of the submission. This approach provides TFASOFT with complete traceability of results, while protecting the user against any unintentional or malicious manipulation of his or her declaration.

In short, the results entry component should offer:

- An **intuitive interface** listing all candidates/parties.
- **Numerical fields for entering results** for each candidate.
- A **validation and confirmation button** before sending.
- Optional upload of up to 10 **images** (photos and videos) of the **minutes, results table,** and any other relevant objects filmed in and around the polling station.

4.2 Consensus management

The consensus mechanism implemented in TFASOFT is the democratic guarantee of the system. It ensures that the results published by the application are not the fruit of an isolated declaration, but rather the convergence of multiple, coherent and independent observations from a representative group of citizens. This system embodies a form of algorithmic decentralization of trust, where validation is not the result of an act of authority, but of an accumulation of converging agreements.

Each polling station is aggregated from the results entered by FAIR users. For each candidate or party, the consensus algorithm assesses whether a sufficient percentage of FAIR users have declared an identical value. This percentage is defined by a configurable constant called *poolConsensusLevel*, whose default value is set at 70% but can be adapted according to the type of poll or degree of requirement desired.

Until this threshold is reached for a given candidate, the score displayed is considered provisional. The visualization interface uses a clear color code to indicate the level of consensus reached for each candidate in a polling station. A green dot indicates total consensus (100%), a yellow dot partial consensus (≥ poolConsensusLevel and < 100%), and a red dot a lack of sufficient consensus (< poolConsensusLevel). This immediate visual code enables any citizen to identify at a glance, areas where the reliability of results is high, low, or to be monitored.

Consensus is dynamic: with each new submission by a FAIR user, the statistics are recalculated and the score adjusted if necessary. As soon as a candidate reaches the required consensus

threshold, its score is automatically promoted to the rank of validated result. This validation can be revoked if, due to a statistical effect, the arrival of new data causes the consensus to fall below the threshold. This self-regulating nature of the consensus guarantees the robustness of the system, with no centralized authority intervening in data processing.

Finally, all status transitions (provisional → validated, validated → provisional) are logged in a historical database and published as read-only via an open API. This mechanism guarantees complete auditability of the validation process, and enables any observer or independent organization to check, in real time or a posteriori, how each result was approved, promoted or contested.

This mechanism is therefore distinguished by the following elements:

- Configurable constant **poolConsensusLevel** (e.g. 70%).
- For each candidate, if ≥ **poolConsensusLevel % of** FAIR users fill in the same score, that score is validated.
- **Results adjust according to new entries** up to the total number of valid FAIR users registered in TFASOFT for the polling station.
- **Visualization interface with colors**:
    - Green: 100% consensus
    - Yellow: between *poolConsensusLevel* and <100
    - Red: below *poolConsensusLevel*

4.3 Web and Mobile visualization

The visualization of results is TFASOFT's public interface and embodies the democratic transparency the software aims to establish. The application adopts a hierarchical, progressive navigation principle, inspired by Cameroon's electoral administrative structure. Starting from a national dashboard, the user can progressively dive down to the most granular level: that of the polling station.

On the home screen, a summary of national results is presented, with aggregated scores for the three leading candidates or parties. A fourth option allows you to consult detailed results for other candidates. The interface uses color coding to visually illustrate the distribution of votes across the country. Interactive tiles, each representing a region, are arranged below the national summary. Each tile displays local trends and the state of consensus in the region concerned.

Clicking on a region takes the user to its constituent departments, with similar visual representations. At each level (region, department, constituency, polling center, polling station), colored dots provide information on the state of consensus, and synthetic graphs show the differences between the scores obtained by the various candidates.

Visual evidence (photos and videos) posted by citizens can be accessed from each level of granularity. In polling stations where consensus is weak or absent, these files can be consulted to support citizen verification. A system of filters can be used to search for polling stations where the consensus is red, in order to focus attention on sensitive points. This function is essential to transparency, as it engages each user in the role of observer and controller.

TFASOFT's Web version is dedicated to this visualization function. It offers fluid navigation and a responsive design adapted to all screens. The Android and iOS applications offer the same consultation functionalities, in addition to those for input and validation. This usage distinction ensures that the server load linked to visualizations does not interfere with critical dispatches from the field.

To complete this subchapter on web and mobile visualization, a detailed description of the interface layout and navigation options is provided in subsections 4.3.1 to 4.3.7. This aspect of the software is based on the following hierarchical structure in accordance with the electoral law in force in Cameroon: 1. Polling station -> 2. Voting center → 3. Electoral district → 4. Department → 5. Region → 6. National level.

4.3.1 Main page (dashboard)

- Header section

At the top of the screen, three large horizontal boxes or circular icons each represent one of the three leading candidates or political parties. These boxes display the total votes for each candidate/party as a percentage and a number, making it easy to compare their support during the election. If there are more than 3 candidates/parties on the ballot, a fourth horizontal box shows the compiled result for the remaining candidates/parties. Clicking on this fourth box brings up the detailed zoom with results and percentages for each of the other candidates.

- Region overview

- Below the header, the screen is divided into a grid of 10 square boxes (one for each region of the country). Each box displays the name of the region and the total votes for the three leading candidates/parties in that region (added together). Results are color-coded according to the leading candidate or party, enabling users to quickly identify the dominant force in each region.

- Each square is clickable, allowing users to delve deeper into the results for that region.

4.3.2 Results page by region

- Clicking on a region's square changes the interface to display results for the region's departments.

- The horizontal boxes at the top of this page are similar to those on the main page. Here, general results and trends for the region are presented.

- Below, the screen displays several small squares (one for each department in the selected region).

- Within each department box, the total votes for the three leading candidates/parties are displayed, along with a color code indicating the strength of these candidates in that department.

- Users can click on any department square to view more detailed data.

4.3.3 Departmental results page

- Clicking on a department square displays the results for that department's electoral districts.

- The horizontal boxes at the top of this page are similar to those on the main page. Here, general results and trends for the department are shown.

- Below, the screen is again divided into several smaller squares, each representing an electoral district in the relevant département.

- Each constituency square shows the total number of votes for the three leading candidates/parties, color-coded to indicate the winner.

- Each constituency square is clickable, enabling even more detailed data at polling center level.

4.3.4 Constituency results page

- Clicking on a constituency square takes the user to the results at polling center level.

- The horizontal boxes at the top of this page are similar to those on the main page. Here, general results and trends for the electoral district are presented.

- Here, each polling center is displayed in its own square, showing the votes for the three leading candidates/parties and the number of polling stations that contributed to the result.

- The layout maintains a clean, minimalist design, displaying only the essential details for easy access.

4.3.5 Polling center results page

- Selecting a polling center square takes the user to the results at polling station level.

- The horizontal boxes at the top of this page are similar to those on the main page. Here, general results and trends for the selected polling center are presented.

- The interface displays smaller boxes representing each polling station in the selected center, with results compiled for the three main candidates/parties.

4.3.6 Polling station results page

- When a polling station box is selected, detailed polling station results are displayed, such as the total number of votes cast and the number of votes for each of the candidates/parties running.

- This screen provides the final level of detail, ensuring that the user can explore election results down to the most granular level.

4.3.7 Aesthetics and navigation:

- The overall look is modern and minimalist, with a white or light background and clear borders around the squares to maintain a clean layout.

- Navigation is intuitive, with each click taking the user through the election results, progressively from general national data to specific polling stations.

- Color coding is used to highlight the main candidates in each area (for example, green, red and yellow), making the data visually comprehensible at a glance.

- Progressive disclosure: the application follows a principle of progressive disclosure, whereby users can delve deeper into the results by clicking on regions, departments, constituencies, etc. without being overwhelmed by too much information at once.

- The design avoids unnecessary clutter by showing just enough data in each section, with clear labels and tooltips where necessary.

This presentation ensures a logical flow of information, from national to local results, while remaining accessible and easy to navigate for users with varied technical skills.

To summarize, the Web and Mobile visualization component meets the following needs:

- **National dashboard** with top three candidates + "others" button.
- **Interactive navigation** down to polling station level.
- Each level displays its own **local statistics and consensus status**.
- Availability of **uploaded photos and videos as evidence**.

4.4 Caching and connection via alternative networks.

The efficiency and resilience of TFASOFT in a critical electoral context requires a robust system for caching and synchronizing data in the absence of an Internet connection. This section describes a technical solution combining local storage mechanisms, alternative peer-to-peer networks (Wi-Fi Direct, Bluetooth Mesh), and deferred synchronization logic with the central TFASOFT server.

First and foremost, when the Internet connection is unavailable, the TFASOFT application must enable the user to complete his or her results normally. All data entered, including numerical fields for each candidate and media files (up to 10 photos or videos), are stored in an embedded local database (e.g. SQLite) secured by AES encryption.

An internal queue is then created to mark this data as "awaiting synchronization". This queue follows a FIFO (First In, First Out) protocol to ensure that the oldest data is synchronized first, as soon as connectivity is restored. A background synchronization process runs periodically to attempt to transmit data to the central server. If the attempt fails, the user at is notified, but the data remains available locally until synchronization is successful.

However, in rural areas or in situations of prolonged network outage, a proximity communication mechanism becomes essential. TFASOFT therefore integrates an alternative network layer based on **Wi-Fi Direct** and **Bluetooth Mesh Networking**. This layer enables several users in close proximity to connect their phones to each other without using the Internet. When a user finishes entering results, the application can transmit this data via Bluetooth Mesh to other TFASOFT-compatible devices in the vicinity.

Each TFASOFT phone then acts as a node in a mesh network, receiving data from one or more users and storing it locally as a temporary proxy. When one of these devices regains an Internet connection, it acts as a relay, uploading not only its own data but also that received from the local network. Each data packet is digitally signed with the unique identifier of the original user to guarantee authenticity and traceability.

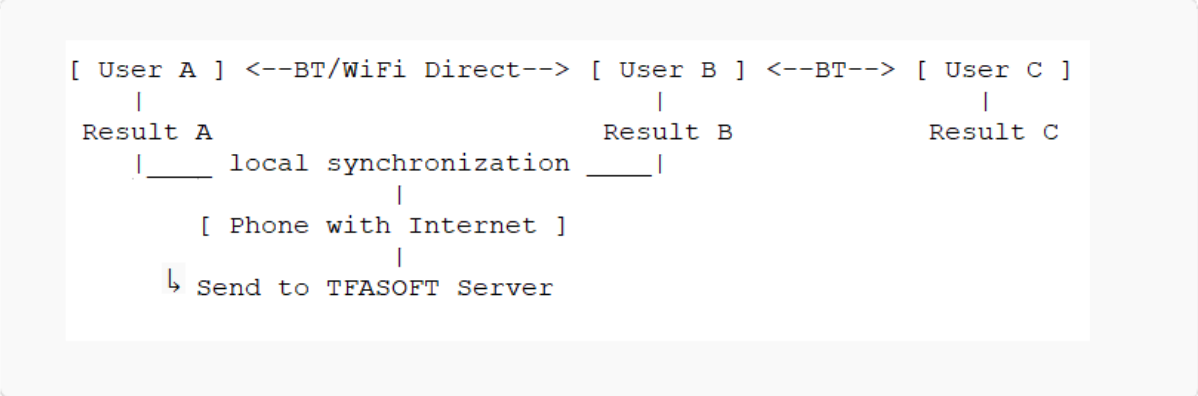

Figure1 : Example of "Network Resilience" architecture for TFASOFT

This multi-level strategy offers exceptional resilience in fragile contexts. It ensures that, even in the complete absence of network infrastructure, a group of users can pool their resources to route information to the processing center as soon as a single phone accesses the Internet. Once synchronization has been successfully completed, the TFASOFT server acknowledges receipt, time-stamps each submission and notifies the original author that his or her data has been taken into account.

This system, transparent to the user, guarantees the integrity and accessibility of electoral data even in the most degraded contexts. It represents an innovative response to the challenges of digital accessibility in rural areas, while reinforcing TFASOFT's mission of citizen transparency.

The system implemented in this way would enable TFASOFT, even in the absence of Internet, to:

- **Aggregate results locally**,
- **Synchronize them as soon as a single device connects**,
- guarantee **resilience, transparency and citizen sovereignty**.

4.5 Citizen alert system

Electoral transparency would not be complete without a citizen watch and denunciation mechanism. TFASOFT's functional architecture incorporates an alert system designed to enable every user to play an active role in monitoring the consistency between declared results and the visual evidence deposited on the platform. Far from being incidental, this system is a key link in the chain of collective responsibility.

In concrete terms, when a user consults the results of a polling station, he or she also has access to the visual files (photos and videos) submitted by the FAIR contributors of that polling station. In the event of an obvious inconsistency - for example, a glaring discrepancy between the figures entered and those displayed on a photo of the minutes - the user can trigger an alert procedure directly from the application's interface. The user just needs to have a TFASOFT account to be able to trigger an alert (so, no need to be FAIR registered for this).

The procedure consists in designating the litigious element(s), associating a freely-written justification, and submitting the whole to the platform. Once received, the alert is automatically listed in a public register that can be consulted by all. This register acts as a directory of disputes, facilitating the monitoring of high-risk situations and guiding future verifications. The aim is not to censor, but to flag and document grey areas so that they can be submitted for collective examination.

In addition, TFASOFT encourages users to share their reports on social networks via integrated share buttons. This approach increases the visibility of anomalies and involves the digital community in the citizen verification process. The impact of whistle-blowing is therefore not limited to the perimeter of the application, but extends to the digital public space, contributing to a multiplied transparency effect.

To preserve the integrity of the process and avoid abusive whistle-blowing, each alert is linked to the unique identifier of the user who initiated it. Repeated unsubstantiated or clearly malicious reporting may result in suspension of the user's account. An alert reliability algorithm can also be integrated, analyzing the recurrence of alerts by zone and their convergence with existing consensuses. Thanks to this regulation, TFASOFT ensures that citizens' speech remains both free and responsible, in the service of a shared objective: to bring out the truth from the ballot box through collective intelligence and participative transparency.

In this way, the citizen alert system highlights the following elements:

- The possibility for any user to **report a visible inconsistency between images and results**.
- Link to a **public reporting page**, automatically updated.
- Encouragement of **publications on social networks** to denounce irregularities.

5. Security, transparency and auditability

The integrity of electoral information cannot be guaranteed without a solid technical foundation ensuring the security, transparency and auditability of all data entry, transmission, validation and consultation operations in TFASOFT. This chapter describes in detail the application security mechanisms, traceability procedures and auditing tools implemented, so that every citizen can be sure that the results consulted in the application faithfully reflect the data actually recorded.

Data security is based on end-to-end encryption. This means that all data entered - whether scores entered for each candidate or attached visual files - is encrypted as soon as it is generated in the mobile application. This data is only decrypted on the TFASOFT servers once it has been received, ensuring that no network interception can compromise its integrity. Encryption is ensured by robust algorithms such as AES-256 for local storage and TLS 1.3 for network transmissions.

In addition, each operation is time-stamped and, if the user consents, geolocated. This metadata is used not only to check the temporal conformity of captures (between 6pm and 10pm on polling day), but also to cross-reference the locations of captures with the official locations of polling stations. This makes it possible to detect any attempt at fraudulent submission from an inconsistent position or outside the authorized timeframe.

To ensure total transparency, TFASOFT logs every consensus modification. Each status transition (provisional result → validated, validated → contested, etc.) is recorded in a historical database with identifier, time, possible justification, and source of modification. These logs are unalterable and searchable via a public, read-only API. They enable any third-party entity - journalists, independent observers, NGOs - to audit the results consolidation process in real time or a posteriori.

For greater transparency, the source code of the entire TFASOFT platform is published under an open license on a public repository (e.g. GitHub). Anyone interested can consult, reuse or audit the lines of code responsible for the system's main functionalities. This openness of the code, combined with API documentation, strengthens confidence in the system and fosters citizen collaboration around the continuous improvement of the tool.

Finally, a strictly controlled access management policy is applied to the entire server infrastructure. Roles are divided between maintenance, audit, moderation and development. Access logs are kept for each administrative operation, and automatic alerts are triggered in

the event of any attempt at unauthorized access. So, the security chain relies not only on technology, but also on rigorous, transparent governance.

To summarize, the following elements are essential for security, transparency and auditability:

- End-to-end **data encryption** (results, images).
- **Time-stamping and geolocation** of recordings (if permitted).
- **Logging** of all consensus modifications.
- **Read-only public API** for observers, ushers, journalists and citizens.
- **Open-source** code published on GitHub.

6. Governance and scalability

TFASOFT's sustainability and effectiveness depend on a flexible, scalable governance architecture based on principles of citizen participation. This chapter explores the mechanisms by which the system's evolution can be organized democratically, while guaranteeing the robustness of the system in the face of a gradual increase in load. The challenge is to enable the software to adapt both to contextual changes (type of poll, data volume, network coverage) and to future user expectations.

The dynamic parameterization of certain key elements of the system, starting with the *poolConsensusLevel* constant, illustrates this desire for flexibility. Depending on polling requirements (presidential, municipal, legislative elections, etc.), or on previous feedback, this value can be adjusted to reflect an appropriate level of rigor or tolerance. This parameter setting can be proposed to TFASOFT's active citizen community for collective validation, illustrating a form of participative governance.

Technically, TFASOFT is designed to support massive scalability. Thanks to a distributed architecture, efficient cloud replication and optimized local caching mechanisms, the system can accommodate several million simultaneous users, without compromising performance or security. Each component of the architecture is designed according to the principles of horizontal scalability, with independent modules that can be replicated or scaled according to traffic.

Continuous improvement of the system also relies on a rigorous observation and evaluation process. Each ballot is used to collect performance indicators, such as participation rates, response times and statistics on whether or not consensus has been reached. These metrics are consolidated in public post-election reports, enabling the community to discuss any necessary adjustments: improving consensus algorithms, redesigning certain interfaces, or adding new levels of administrative hierarchy.

Finally, TFASOFT's scalability is guaranteed by its modularity. The software architecture makes it easy to add new modules, such as a litigation observatory, an analytical dashboard for the

media, or a layer of artificial intelligence to anticipate fraud risks. This modularity means that TFASOFT is not locked into a narrow functional perimeter, but can evolve into a genuine digital citizen ecosystem capable of providing lasting support for the democratic reform underway.

This chapter has highlighted the following key aspects:

- Dynamic parameterization of ***poolConsensusLevel*** according to the type of election.
- Capacity to **support millions of simultaneous users**.
- Observation of the effectiveness of the implemented mechanisms with a view to **improving consensus rules in the** future.
- **Modular system for integrating different types of elections** (presidential, legislative, municipal, etc.).

7. TFASOFT system architecture

The TFASOFT system architecture is designed to meet stringent requirements in terms of resilience, performance and security, as well as readability and interoperability. It seamlessly articulates various technical components divided between user interfaces, data processing, secure storage, synchronization and auditability. This chapter presents all the software and hardware layers that make TFASOFT operational and robust, and illustrates their relationships in an overall diagram.

At the apex of this architecture are the user interfaces. On the one hand, the mobile application (Android/iOS) is the main tool for FAIR citizens: it enables them to enter results, attach visual evidence, check local consensus and consult results all the way to their polling station. On the other hand, the web interface, accessible to the general public, offers a complete and interactive visualization of aggregated results, with the possibility of exploration by hierarchical levels (region, department, constituency, center, office).

The heart of the system is a centralized **backend/API** server, which orchestrates all data exchanges between mobile applications, database et media storage systems. This backend handles critical functions such as consensus consolidation, status transition logging, image and metadata processing, as well as interfacing with security modules. It is designed to be modular and redundant, capable of operating on a multi-region cloud infrastructure (e.g. AWS, GCP, DigitalOcean) with automatic scalability mechanisms.

Data storage is organized according to a hybrid model. On the one hand, a relational database (e.g. PostgreSQL) manages the hierarchical structure of polling stations, users, numerical scores, consensus statuses, citizen alert reports, audit logs and aggregated statistics. On the other hand, a Multimedia database (e.g. AWS S3) stores media files. These two databases are synchronized via software abstraction layers, guaranteeing consistency and speed.

In parallel, TFASOFT integrates a **local cache system** embedded in the mobile application (e.g. SQLite) to ensure resilience in the event of network interruption. This module handles data

queuing, local encryption and automatic synchronization as soon as an Internet connection is detected. This component is backed up by an alternative network layer (Bluetooth Mesh or Wi-Fi Direct) that enables inter-device communication in the absence of connectivity, and data routing to a connected device acting as a relay.

Finally, **read-only access** is provided via a **public API**, enabling observers, journalists and developers to consult consensus status, recorded results, global statistics and alerts. This API guarantees real-time auditability and is accompanied by open, documented source code, hosted on a public platform (GitHub), reinforcing the system's total transparency.

The following figure illustrates this distributed, interconnected architecture in its entirety:

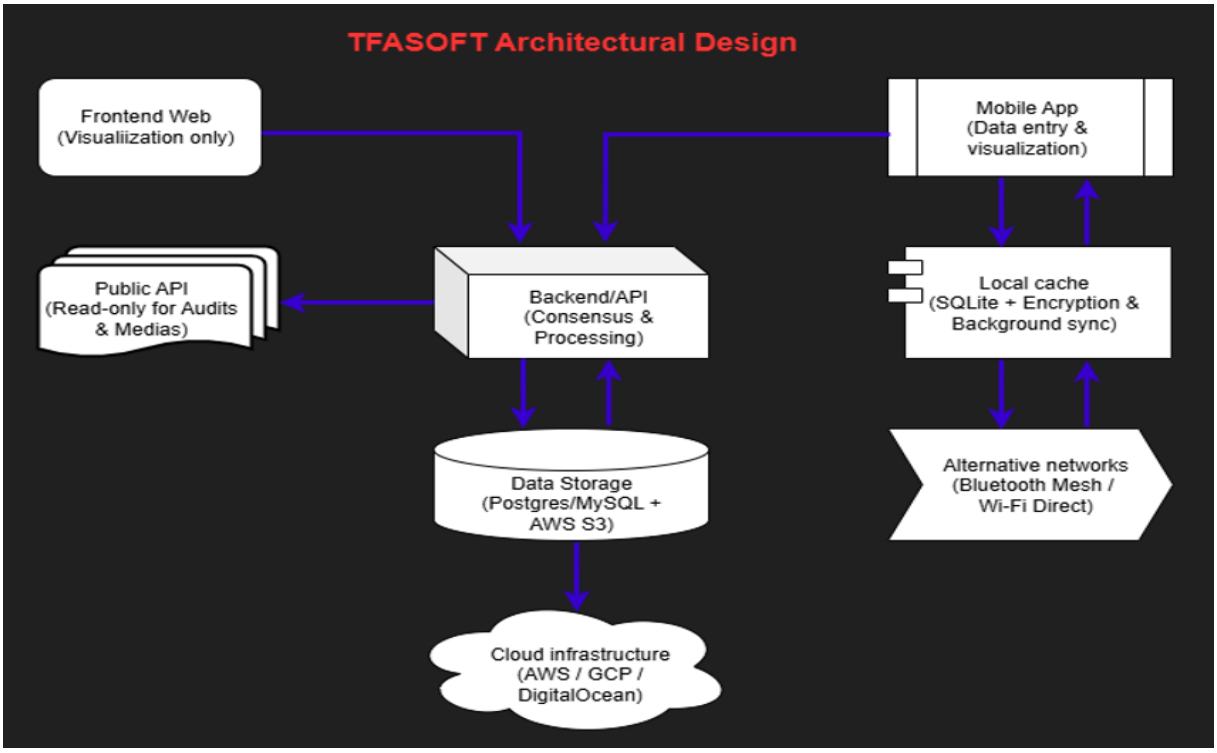

Figure 2: System architecture of TFASOFT.

This architecture enables TFASOFT to combine flexibility of use, technical robustness and citizen transparency. It meets the project's founding mission: to make every citizen a stakeholder in the electoral process, and to ensure that published results are verifiable, justifiable and indisputable.

In summary, the following points of the TFASOFT architecture were described:

- **Web front-end**: Component accessible only for viewing results. Progressive navigation to the polling station. Technologies: React.js or Vue.js.
- **Mobile application (Android/iOS)**: Viewing and input interface, photo and video capture, validation. Technologies: Kotlin, Java (Android), Swift (iOS), Flutter or React Native.

- **Back-end/API**: Centralized server for data management, consensus, calculations and synchronization. Technologies: Springboot, grails, Node.js, Django or Laravel.
- **Data storage**: PostgreSQL or MySQL for relational structure. Amazon S3 for flexible storage of multimedia content. Possibility of making access to the database public in read-only mode, so that anyone can supervise or check incoming and outgoing data flows at any time, and ensure that the information contained in the database is not manipulated by anyone. This system could be placed entirely on a blockchain in the future.
- **Local cache**: Temporary storage in the mobile application with deferred synchronization (e.g. SQLite + background sync) to ensure application resilience in the event of an Internet outage.
- **Cloud infrastructure**: Secure cloud server with data replication (AWS, GCP or DigitalOcean).

8. Conclusion

TFASOFT represents a democratic revolution for Cameroon. Thanks to its decentralized architecture, citizen governance and self-verification capabilities, it is reconciling the population with the truth of the ballot box. By offering a system where every vote counts and every result is verifiable by all, TFASOFT sets a precedent for a new electoral era in Africa.